

## Method for Producing a Laser Mark on Reflective Material

### FIELD OF THE INVENTION

The present invention relates to a method for producing a visible mark on reflective material by laser beams, more particularly to a method for producing a laser mark on reflective material of a base object by laser beams, wherein a plurality of images on the same laser mark can be observed only from different view angles.

### 10 BACKGROUND OF THE RELATED ART

The marks (markings, also referred as "labels") used for products shall be beautiful and durable, and more important to prevent themselves from counterfeit. Therefore, laser marks used for some brand-name products are usually produced greatly difficultly. Some laser marks with patterns and characters are produced on the ready-made commercial reflective material by laser beams. For the laser marks on clothes, the reflective material such as cloth base, plastic film base and the like is generally used so that these laser marks can be washed together with the clothes many times.

As shown in Fig. 1, the generally commercial reflective material 100 is composed of a base body 11, reflective bodies 12 and a support layer 13 by which the reflective bodies are fixed on the base body. The base body 11 may be clothes, paper or plastic film and the like, while the reflective bodies 12 may be spherical transparent objects. In the case that the reflective bodies are spherical, the reflex action (reflected light) is obtained by the support layer indeed since the reflective bodies can only refract light. In the structure shown in Fig. 1, the incident light rays from any direction will be reflected

back in the same direction.

The reflex action of a polyhedral reflective body 14 is different from that of the spherical reflective body 12. As shown in Fig. 2, the polyhedral reflective body 14 may be a tetrahedral reflective body. Specifically, the 5 incident light rays normal to one surface (i.e. incident surface) of the tetrahedral reflective body are total reflected back by the inner side of the tetrahedral reflective body, and then are directed out from the incident surface. So, the reflection principles shown in Fig. 1 and Fig. 2 are absolutely different.

10 The methods for producing a visible mark on reflective material by laser beams have been known for a long time. For example, US 6,231,196 B1 filed in 1997 discloses a method for simply vaporizing part of the light reflective substance on the associated region of the reflective material by laser beams so as to form a mark with dark patterns and characters on a bright 15 background. US 6,217,175 B1 filed in 1998 discloses an improved method for flattening the bottoms of the spherical reflective bodies on the associated region of the reflective material by laser ablation, so that the observer can see the dark patterns and characters in a direction normal to the plane of the reflective material, while the observer cannot see any pattern or character but 20 only a bright background from a direction deviating from the normal direction with a certain angle.

Fig. 3 is a view for illustrating the reflection principle of spherical reflective bodies 12 in the prior art, each having a flat bottom formed by laser ablation. As shown in Fig. 3, the bottoms of the spherical reflective 25 bodies 12 are made to be plane, and there is not a support layer to play a reflective role. Thereby, when incident light rays enter the reflective material

in a direction normal to the reflective material, they will not undergo the reflection, thus, no reflective light rays but dark patterns and characters can be seen by the observer within a certain range, such as 30° shown herein, which depends on the diameter of the plane. And no patterns and characters 5 but a bright background can be seen if out of this range. Thus, the method in the prior art is just to destroy the reflective characteristic of the bottoms of the associated spherical reflective bodies 12, that is, to destroy the reflective characteristics of the first emergent surface and the second incident surface for the incident light rays, so that the incident light rays cannot be reflected 10 back thereon. Since each spherical reflective body 12 has only one bottom, the method in the prior art can only produce at most one mark on the same spherical reflective body 12.

The mark produced by the first method is so easy to be faked. In addition, while the reflective substance is vaporized by the laser beam 15 normal to the reflective material, the bared support layer around the reflective substance tends to be damaged by the laser beam. Actually, this method doesn't bring any special optical effect, just like etching a mark on a surface of a bowl. The above-mentioned second method can not be applied to polyhedral reflective bodies but only to the spherical reflective bodies, 20 although it can bring a certain optical effect. Furthermore, it is inconvenient to flatten the bottom of ready-made the spherical reflective bodies of opaque base-body reflective material. And this process may destroy the original base body of the reflective material. Therefore, it is unpractical for the middle and small manufacturers to accept this method since they often purchase the 25 ready-made reflective material. To get things worse, the structural characteristic of the reflective material cannot be fully utilized, so the laser

mark is not difficult to counterfeit.

## **SUMMARY OF THE INVENTION**

An object of the present invention is to provide a simple method for 5 producing a laser mark on the ready-made reflective material, which can overcome the disadvantages that the method in the prior art is complicated and thereby is too difficult to use ready-made reflective material; its process is only applicable to spherical reflective bodies; and its optical effect is not good and it is easy to counterfeit. By the method according to the invention, 10 laser marks made of the ready-made reflective material which is purchased by the manufacturers can be designed and produced with excellent optical effect and high difficulty of counterfeit.

The above-mentioned object of the invention may be achieved by the following measures:

15 A method for producing a laser mark on reflective material, by which the laser mark provided with a pattern that may be processed and observed is formed on the reflective material with reflective bodies, characterized in that in accordance with the pattern an laser beam selectively scans and irradiates the reflective bodies at an incident angle, so that the irradiated surfaces of 20 the reflective bodies are vaporized to form rough surfaces, while the nonirradiated surfaces of the reflective bodies are still of reflective surfaces, thereby the pattern is formed on the laser mark through the combination of the dark spots corresponding to the rough surfaces and the bright spots corresponding to the reflective surfaces, and may be observed at the incident 25 angle of the laser beam.

In the method, a laser beam selectively scans and irradiates the sides of

a selected group of reflective bodies at an incident angle, so that the irradiated surfaces of the reflective bodies are vaporized to form first rough surfaces, and then a laser beam selectively scans and irradiates the sides of another selected group of reflective bodies at another incident angle, so that

5 the irradiated surfaces of the reflective bodies are vaporized to form second rough surfaces, wherein the first rough surfaces and the second rough surfaces overlap incompletely, and the nonirradiated surfaces of the reflective bodies are still of reflective surfaces, thereby two patterns are formed respectively on the laser mark through the respective combination of

10 the dark spots corresponding to the first rough surfaces or the dark spots corresponding to the second rough surfaces and the bright spots corresponding to the reflective surfaces, and may be observed respectively at the incident angles of the two laser beams.

The incident angle is selected in a range from 10° to 80°.

15 The two incident angles are the same.

The two incident angles are different.

The method further includes the step that a laser beam selectively scans and irradiates the sides of a  $n^{\text{th}}$  selected group of reflective bodies at a  $n^{\text{th}}$  incident angle, so that the irradiated surfaces of the reflective bodies are vaporized to form a  $n^{\text{th}}$  rough surfaces, wherein the first to  $n^{\text{th}}$  rough surfaces overlap incompletely with each other, and the nonirradiated surfaces of the reflective bodies are still of reflective surfaces, thereby  $n$  patterns are formed respectively on the laser mark through the respective combination of the first dark spots corresponding to the first rough surfaces, the second dark spots corresponding to the second rough surfaces till the  $n^{\text{th}}$  dark spots corresponding to the  $n^{\text{th}}$  rough surfaces and the bright spots corresponding to

the reflective surfaces, and may be observed respectively at the incident angles of the  $n$  laser beams, wherein  $n$  is an integer more than 2.

The  $n$  incident angles are the same.

The  $n$  incident angles are different.

5 The reflective bodies are spherical.

The reflective bodies are polyhedral.

The invention has the advantages over the prior art as follows:

1. By using the method for producing a laser mark on the reflective material according to the present invention, a plurality of patterns may be

10 formed on the same reflective material by means of the structural characteristic of the reflective material, thereby the different images on the laser mark may be observed from different angles.

2. The ready-made commercial reflective material having spherical reflective bodies or polyhedral reflective bodies can be used in the method 15 according to the invention.

3. The laser mark with excellent optical effect and high difficulty of counterfeit can be produced by the method according to the present invention.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of conventional reflective material with spherical reflective bodies;

Fig. 2 is a view for illustrating the reflection principle in conventional reflective material with polyhedral reflective bodies;

25 Fig. 3 is a view for illustrating the reflection principle in spherical reflective bodies in the prior art, each having a flat bottom formed by laser

ablation;

Fig. 4 is a schematic view for illustrating a state that a mark is formed on a reflective material by laser ablation according to the method of the invention;

5 Fig. 5 is a schematic view for illustrating different incident angles of laser beams selected in the method of the invention; and

Fig. 6 is a view for illustrating optimum modes for observing the laser mark produced by the method of the invention.

## 10 **DESCRIPTION OF PREFERRED EMBODIMENTS**

Fig. 4 is a schematic view for illustrating a state that a mark is formed on reflective material by laser ablation according to the method of the invention. Although there are spherical reflective bodies 12 shown in Fig.4, the method is also applicable for polyhedral reflective bodies 14. The laser 15 beams can irradiate at least a range larger than the spherical surface of one reflective body 12. In the invention, the laser beams shown in Fig.4 do not irradiate the reflective bodies 12 in a direction normal to the bottoms of the reflective bodies 12, but irradiates first incident surfaces of the upper portions of the reflective bodies 12 at any oblique incident angle, for 20 example between 10° to 80°. Accordingly, the minor rough areas caused by vaporization are formed on the first incident surfaces so that the incident light rays are scattered or refracted in several directions, instead of reflected toward the incident direction. Hence, while the mark is observed in the incident direction, the rough areas caused by vaporization are shown as dark 25 spots and the other areas nonirradiated by the laser beams are shown as bright spots. The advantage of the laser beams obliquely irradiating the

reflective bodies is that there are at least two irradiated surfaces BD and AC overlapping incompletely with each other on the same spherical reflective body 12, wherein the cambered surface CD is an overlapping portion and the cambered surfaces BC and AD are nonoverlapping portions. Thus, two  
5 different marks may be formed in the following way. Firstly, the certain sides of each group of reflective bodies are selectively vaporized by a laser beam with an incident angle to form rough surfaces, and then another certain sides of said each group of reflective bodies are selectively vaporized by a laser beam with another incident angle to form rough surfaces. Since the rough  
10 surfaces and unrough surfaces are shown as dark spots and bright spots respectively due to the different reflectivity therebetween, a lot of dark spots and bright spots with different distribution densities can constitute a picture. Therefore, different images can be recorded and showed by means of more than one surfaces on the same reflective body.

15 In addition, according to the pattern of the laser mark, another group of reflective bodies may be selected, and then the surfaces of the selected group of reflective bodies are irradiated by a laser beam with an incident angle. Accordingly, another combination of rough surfaces and unrough surfaces is created so that a pattern of another image is formed.

20 Hence, a laser mark with a plurality of images, which can be observed only from different view angles, may be formed on the reflective material by laser beams.

25 Similarly, as long as the reflective bodies still have unrough surfaces, a plurality of different patterns may be formed theoretically, but the distinguishability will be lower.

If the reflective bodies are polyhedral bodies, a larger number of

patterns may be formed on the same reflective material due to the different postures of polyhedral bodies, but their luminosity and contrast will become poorer.

Fig. 5 is a schematic view for illustrating different incident angles of laser beams selected in the method of the invention. In Fig.5, five spherical reflective bodies 12-1, 12-2, 12-3, 12-4 and 12-5 are shown from right to left. The upper half arc of the spherical reflective body 12-2 is irradiated by the laser beams with an incident angle of  $30^\circ$  from left and right sides. As shown in Fig. 5, for the right upper half portion of the spherical reflective body, only the cambered surface between the intersection point A, which is formed by the surface of the spherical reflective body 12-2 and the lowermost light ray from the right side, and the tangent point D, which is formed by the surface of the spherical reflective body 12-2 and the uppermost light ray from the left side, is not irradiated by the two laser beams together. That is, the cambered surface is irradiated only by the laser beam from the right side. Similarly, the spherical reflective body 12-3 is irradiated by the laser beams with an incident angle of  $45^\circ$  from left and right sides, and the spherical reflective body 12-4 is irradiated by the laser beams with an incident angle of  $60^\circ$  from left and right sides. Thereby, the larger the incident angle is, the larger the nonoverlapping area (i.e. AD cambered surface) of left-side and right-side light rays is, and the larger the nonirradiated area is. The spherical reflective body 12-5 is irradiated by the laser beams with an incident angle of  $30^\circ$  from right side and an incident angle of  $60^\circ$  from left side. Although there is the largest nonoverlapping area AD at the right upper half of the spherical reflective body 12-5, no nonoverlapping area exists on the left upper half thereof. Therefore, it is preferable that each of the incident angles

of the left-side and right-side laser beams is  $45^\circ$  and thereby both the left and right marks can have the optimum resolution. Certainly, for the sake of secrecy, the difficulty of counterfeit will be increased because of using the left-side and right-side laser beams with different incident angles.

5        Although the overlapping area of the left-side and right-side light rays is large on the top of each spherical reflective body in Fig.5, a large amount of light rays will be reflected out and only a little light rays can enter the spherical reflective body when the light rays irradiate the medium such as glass and the like with a large incident angle. Thus, the phenomenon that the  
10      left-side and right-side light rays overlap each other is not so serious as that shown in Fig.5.

      The computer and the laser generator employed in the method of this invention are well known. For example, the laser generator may be NdYAG, CO<sub>2</sub> or diode-pumped laser generator and the like, and the computer is used  
15      to control the laser generator and the laser reflection scanning device. The reflective material tape on the market is often in a roll. When the reflective material tape is transferred by an intermittent type reel device and stopped at the processing position, the tape is scanned and processed by laser beams. When the laser beams with appropriate intensity scan each group of  
20      reflective bodies 12 or 14 in turn, the irradiated surfaces of the group of reflective bodies become rough by vaporization. Thereby, the group of reflective bodies will be observed as dark spots from this angle, and the unscanned reflective bodies will be observed as bright spots. A lot of dark spots and bright spots with different densities constitute a picture. In order to  
25      increase the production speed, it is preferable that one laser device is used as the left-side light source and the other laser device is used as the right-side

light source. If the area of a laser mark is of 1.5 cm height and 5.0 cm width and the energy of the laser beams is 10 watt, the scanning process can be completed in 30 seconds. These are just experimental data of the invention. In fact, the processing time may be different due to the quality of the 5 reflective material, the complexity of the pattern, the type of the laser, the angle of the incident light rays and the like.

While being examined or watched, the laser mark 100 produced by the method according to the invention can be most clearly observed only on condition that the illuminating light rays irradiate the mark 100 in the 10 directions of the laser beams for processing and the observer looks the mark 100 from the said directions too, as shown in Fig.6. For example, as shown in Fig. 6, the image of the right portion of the laser mark according to the invention is formed by the laser beam scanning with an incident angle of 60° , and thus the optimum observation effect can be obtained only on 15 condition that both the illuminating light rays (indicated by a electric torch in Fig.6) and the observer (indicated by an eye) are in the direction of the laser beam with an incident angle of 60° . The image of the left portion of the laser mark shown in Fig. 6 is formed by the laser beam scanning with an incident angle of 30° , and thus the optimum observation effect can be 20 obtained only on condition that both the illuminating light rays and the observer are in the direction of the laser beam with an incident angle of 30° . In Fig.6, the images in the bright background observed from two different directions are completely different, for example one is a character and the other is a pattern.

25 Herein, the “incident angle” in the description refers to an acute angle between the direction of the incident light rays and the direction normal to

the plane of the reflective material.

## **INDUSTRIAL APPLICABILITY**

By using the method for producing a laser mark on reflective material  
5 according to the present invention, a mark with a plurality of patterns may be  
formed on the same reflective material by means of the structural  
characteristic of the reflective material, so that different images on the laser  
mark may be observed from different view angles. The ready-made  
commercial reflective material having spherical reflective bodies or  
10 polyhedral reflective bodies can be used in the method of the invention. The  
laser mark with excellent optical effect and high difficulty of counterfeit can  
be produced by the method according to the present invention.